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**DEVELOPMENT OF SHORT WAVELENGTH INFRARED ARRAY  
DETECTORS FOR SPACE ASTRONOMY APPLICATIONS**

**NASA Grant NAGW-2868**

**Final Report**

**For the period 1 January 1992 through 30 September 1996**

**Principal Investigator**

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Washington DC 20546**



# DEVELOPMENT OF SHORT WAVELENGTH INFRARED ARRAY DETECTORS FOR SPACE ASTRONOMY APPLICATIONS

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The Smithsonian Astrophysical Observatory (SAO) and its team -- the University of Arizona (UA), the University of Rochester (UR), Santa Barbara Research Center (SBRC), Ames Research Center (ARC), and Goddard Space Flight Center (GSFC) -- are carrying out a research program with the goal of developing and optimizing infrared arrays in the 2 - 27  $\mu\text{m}$  range for space infrared astronomy. This report summarizes research results for the entire grant period 1 January 1992 through 30 June 1996. Additional details may be found in the various technical documents and memos issued during the period. A list of these can be found at the end of this report (Attachment A).

### Band 1 Detector Array Development

Under the overall leadership of SAO, the UR and SBRC, with support from ARC, worked to advance the state of the art in indium antimonide (InSb) detector arrays (Sensor Chip Assemblies - SCAs) for spaceborne applications in the 2 - 5  $\mu\text{m}$  wavelength range. Significant improvements were achieved across the range of detector performance characteristics at temperatures as low as 10 K. These include:

- Development of gateless InSb SCAs in 256 x 256 pixel format.
- Identification of InSb material characteristics essential to achieving high QE and low dark current at temperatures below 10K. Evaluation of InSb material from four vendors (Johnson-Matthey, Firebird, Cominco, Sumitomo) to identify suitable primary and backup vendors for flight SCAs
- Exploration of a variety of different detector passivations to allow use of the gateless detector configuration.
- Development of new and reliable methods to thin InSb detectors uniformly to  $7 \pm 1 \mu\text{m}$ .
- Development of new low-noise readout multiplexers (the CRC-590, -644 and -744) for operation in the 10 - 15 K range.
- Achievement of dark currents  $< 0.2$  electrons/second and read noise of  $< 6$  electrons at these temperatures.
- Development and implementation of multiple sampling readout techniques.
- Demonstration that the selected detector and multiplexer designs were compatible with typical space application gamma and proton radiation environments.

The advances in performance in key InSb SCA performance parameters are shown in the following table.

Parameter	Typical January 1992 Performance	Typical June 1996 Performance
Array Size (pixels)	58 x 62	256 x 256
Pixel Size (microns)	76	30
Quantum Efficiency @ 3.3 $\mu\text{m}$ and 10K (%)	> 45	> 80
Dark Current @ 10 K(e/s)	< 1.0	< 0.2
Read Noise @ 10 K (e <sup>-</sup> )	280	< 10

## Band 2 Array Evaluation

Under the overall leadership of SAO, ARC and SBRC, with support from UR, worked to advance the state of the art in arsenic-doped silicon (Si:As) SCAs for spaceborne applications in the 5 - 28  $\mu\text{m}$  wavelength range. Band 2 work under this grant focused on the evaluation of SCAs in 20 x 64, 58 x 62, 128 x 128 formats from Rockwell and SBRC (then Hughes). Our goal was the selection of a design approach to use in 256 x 256 Si:As SCAs to be developed under related contracts from ARC and SAO.

Significant improvements were achieved across the range of detector performance characteristics at temperatures in the 4 - 8 K range. These include:

- Achievement of the required 256 x 256 format.
- Significant reductions in read noise and dark current to levels required for the SIRTf mission.
- Demonstration that the selected detector and multiplexer designs were compatible with typical space application gamma and proton radiation environments.

The advances in performance in key Si:As SCA performance parameters are shown in the following table.

Parameter	Typical March - June 1992 Performance	Typical June 1996 Performance
Array Size (pixels)	128 x 128	256 x 256
Pixel Size (microns)	75	30
Detective Quantum Efficiency @ 5.5 K (%)	20	> 20
Dark Current @ 4.2 K(e/s)	12	< 3
Read Noise @ 8 K (e <sup>-</sup> )	130	60

## Instrument Optical Design and Packaging

We explored a variety of optical designs during the grant period directed at understanding the weight and volume characteristics of instruments with and without filter wheels and with reflective and refractive optics. We also initiated design of an instrument in support of a possible collaboration between SIRTf and a Japanese mission called the Infrared Imaging Survey (IRIS).

For the first, our studies showed that in general, instruments using filter wheels were lighter, smaller and simpler than equivalent designs without them. Cryogenic mechanisms may be a significant risk factor, however, and can add cost to a mission. Refractive systems were shown to be smaller and lighter than equivalent reflective systems but are more difficult to realize due to lack of knowledge of the materials' index of refraction at cryogenic temperatures.

For the Japanese mission, requirements were defined and initial design studies initiated. As this report is written, those studies are nearing completion and a preliminary report will be submitted to NASA in October. Additional information in these studies is available in the reports prepared during this period (see Attachment A).

## Optical Component Development

Development and evaluation of a beamsplitter to separate Band 1 and Band 2 light was the focus of this effort.

Two runs of beamsplitters were done at OCLI, Inc. The first exhibited excessive bowing when cooled. The second run, with a thicker substrate, showed acceptable performance. The room temperature front surface shape based on reflection measurements exhibited a slight astigmatic and convex spherical distortion. Measurements at the University of Arizona showed that the change in surface shape of OCLI beamsplitter Model 2 SN#1 from room temperature to 12.5 K was minor and that the room temperature shape can be used for evaluating the beamsplitter effect on IRAC optical performance. The results were reported in IRAC93-4003.

Tests at 14 K by OCLI showed transmission at 28  $\mu\text{m}$  was maintained high at 54% with a maximum total ripple of  $\pm 10\%$ . The average transmission was 68.3% from 6.0 to 28  $\mu\text{m}$  with one significant dip to 38% at 6.1  $\mu\text{m}$ . Reflection was also maintained high with measured values of 84% from 1.3 to 1.8  $\mu\text{m}$  and 91.5% from 1.8 to 5.3  $\mu\text{m}$ . Dips in reflection were found at 1.19  $\mu\text{m}$  (to 10%) and at 2.28 and 2.57  $\mu\text{m}$  (both to 60%). Elsewhere in the reflection band, ripples in reflection were limited to  $\pm 5\%$ .

## Calibration Source Development

Goddard Space Flight Center developed a polysilicon calibration source suitable for short-wavelength use which dissipated less power than previous devices. The new design is based on source designs developed for the Diffuse IR Background Experiment (DIRBE) experiments on the COBE mission. The new design uses polysilicon emitters initially deposited on silicon dioxide. The silicon dioxide layer is later etched away to yield free-standing polysilicon filaments. The resulting devices have been successfully run in air for long (> 24 hours) periods of time and

reached 1000 K with 20 - 30 mW of input power. Under vacuum, the input power requirement will drop to under 10 mW.

ATTACHMENT A  
LIST OF TECHNICAL DOCUMENTS AND MEMORANDA RELEASED  
1 JANUARY 1992 - 30 JUNE 1996

<b>IRAC 000-099</b>	<b>Telescope and Spacecraft Documents</b>
IRAC95-001	"SIRTF Baseline Compatible Telescope Mount-Conceptual Design" G.-S. Shen, R. Parks 15 August 1995
<b>IRAC 100-199</b>	<b>Program Management and Planning Documents</b>
IRAC96-001	"Space Infrared Telescope Facility, Preliminary Non-Advocate Review" JPL 26-27 June 1996
IRAC96-002	"The Infrared Spectrograph (IRS), Version 2.0" J.R. Houck, Cornell 14 June 1996
IRAC91-112	"IRAC Project Review - Instrument Conceptual Design, November 5, 1991 at GSFC" Team March 1992
IRAC91-113	"Request for Proposal to the University of Arizona for Technology Development of Optical Components for Spaceborne Astronomy Applications" R.S. Taylor 27 November 1991
IRAC91-116	"IRAC Conceptual Design Review" Team March 1992
IRAC92-101	"SIRTF SWG Meeting #23, 16-18 March 1992" Team March 1992
IRAC92-102	"SIRTF Payload and Facility Meeting at JPL, 24 April 1992" Team April 1992
IRAC92-103	"SIRTF2 Status Review Meeting at JPL, 6 May 1992" May 1992
IRAC92-104	"SIRTF2/IRAC Optical Design Kickoff Meeting, 28 May 1992" Team 29 May 1992
IRAC92-105	"SIRTF Project Meeting at JPL, 29 May 1992" Team June 1992
IRAC92-106	"SIRTF SWG Meeting #24, 29-30 June and 1 July 1992" Team July 1992
IRAC92-107	"SIRTF SWG Meeting #25, 24-25 August 1992" Team September 1992
IRAC92-108	"RFP to the Advanced Technology and Research Corporation for Optical Design of an Infrared Array Camera" R.S. Taylor 28 September 1992

IRAC92-109	"RFP to the University of Arizona for continuation of Technology Development of Optical Components for Spaceborne Astronomy Applications" R.S. Taylor	21 October 1992
IRAC92-110	"RFP to the University of Rochester for continuation of Short Wavelength Infrared Array Detector Technology Development for Spaceborne Astronomy Applications" R.S. Taylor	21 October 1992
IRAC92-111	"RFP to Santa Barbara Research Center for continuation of Short Wavelength Infrared Array Detectors for Space Astronomy" R.S. Taylor	21 October 1992
IRAC92-112	"RFP to the Advanced Technology and Research Corporation for Optical Design Updates and Packaging of an Infrared Array Camera" R.S. Taylor	4 November 1992
IRAC92-113	"SIRTF SWG Meeting #26, 1-2 December 1992" Team	December 1992
IRAC92-114	"IRAC Technology Review at GSFC, 16 December 1992" Team	December 1992
IRAC93-101	"SIRTF Payload Working Group and Science Working Group Meetings, 21-23 April 1993" Team	April 1993
IRAC93-102	"IRAC Internal Status Review, 15 June 1993" Team	June 1993
IRAC93-103	"28th SIRTF Science Working Group Meeting, 11-12 August 1993, at Cornell University" Team	August 1993
IRAC93-104	"RFP to University of Rochester for Continuation of Short Wavelength Infrared Array Detector Technology Development for Spaceborne Astronomy Applications" R.S. Taylor	9 November 1993
IRAC93-105	"RFP to University of Arizona for Continuation of Technology Development of Optical Components for Spaceborne Astronomy Applications" R.S. Taylor	9 November 1993
IRAC93-106	"29th SIRTF Science Working Group Meeting, 2-3 December 1993" Team	December 1993
IRAC93-107	"SIRTF Payload Working Group Meeting #3 at GSFC, May 25, 1993" Team	January 1994
IRAC94-101	"SIRTF Science Working Group Meeting, 16-17 December 1993" Team	January 1994

IRAC94-102	"SIRTF Short-Wavelength Mission Informal Design Report" Team February 1994
IRAC94-103	"SIRTF Peer Review Preview at the Jet Propulsion Laboratory, 24-25 January 1994" Team February 1994
IRAC94-104	"RFP to the University of Rochester for participation in "Phase A Concept Definition of an Infrared Array Camera (IRAC) for the Space Infrared Telescope Facility (SIRTF) and the development of array detectors for the camera" R.S. Taylor 2 May 1994
IRAC94-105	"RFP to the University of Arizona for participation in "Phase A Concept Definition of an Infrared Array Camera (IRAC) for the Space Infrared Telescope Facility (SIRTF) and the development of array detectors for the camera" R.S. Taylor 3 May 1994
IRAC94-106	"RFP to Ames Research Center for participation in "Phase A Concept Definition of an Infrared Array Camera (IRAC) for the Space Infrared Telescope Facility (SIRTF) and the development of array detectors for the camera" R.S. Taylor 2 May 1994
IRAC94-107	"RFP to Goddard Space Flight Center for participation in "Phase A Concept Definition of an Infrared Array Camera (IRAC) for the Space Infrared Telescope Facility (SIRTF)" R.S. Taylor 3 May 1994
IRAC94-108	"RFP to Evans Engineering for participation in "Phase A Concept Definition of an Infrared Array Camera (IRAC) for the Space Infrared Telescope Facility (SIRTF)" R.S. Taylor 3 May 1994
IRAC94-109	"RFP to Santa Barbara Research Center for participation in "Phase A Concept Definition of an Infrared Array Camera (IRAC) for the Space Infrared Telescope Facility (SIRTF) and the development of array detectors for the camera" R.S. Taylor 4 May 1994
IRAC94-110	"RFP to Hughes Technology Center for a Rough Order of Magnitude (ROM) estimate of costs for participation in "Phase A Concept Definition of an Infrared Array Camera (IRAC) for the Space Infrared Telescope Facility (SIRTF) and the provision of flight array detectors for the camera" R.S. Taylor 27 May 1994
IRAC94-111	"SIRTF Science Working Group Meeting (#30) 5-6 May 1994 at CalTech" Team June 1994

IRAC94-112	"SIRTF/IRIS Collaboration Initial Exploratory Meeting/IRIS Mission Description, June 20-21, 1994, at the Institute for Space and Astronautical Science, Tokyo, Japan"	Team	June 1994
IRAC94-113	"RFP to the University of Rochester for added scope and an extension to Contract SV2-62008, "Short Wavelength Infrared Array Detector Technology Development for Spaceborne Astronomy Applications""	R.S. Taylor	8 August 1994
IRAC94-114	"RFP to Evans Engineering for added scope and an extension to Contract SV2-62005 "Optical Design Updates and Packaging of an Infrared Array Camera""	R.S. Taylor	8 August 1994
IRAC94-115	"IRAC/IRIS Technical Meeting at Goddard Space Flight Center, 2 August 1994"	Team	August 1994
IRAC94-116	"SIRTF SWG Meeting #31, 8-10 September 1994, Washington, DC"	Team	September 1994
IRAC94-117	"SIRTF Reports to NASA-ISRMOWG, October 27, 1994"	M. Werner, G. Fazio, G. Rieke	November 1994
IRAC95-101	"SIRTF SWG Meeting, 13-14 February 1995, Washington, DC"	Team	February 1995
IRAC95-102	"SIRTF SWG Meeting, 9-10 May 1995, Pasadena, CA"	Team	May 1995
IRAC95-103	"SIRTF Payload Working Group Meeting at Goddard Space Flight Center", Team		14 September 1995
IRAC95-104	"SIRTF SWG Meeting, 12-13 September 1995 at NASA Headquarters"	Team	October 1995
IRAC95-105	"Request for Proposal to Santa Barbara Research Center for Infrared Array Detectors for the SIRTF Infrared Array Camera"	SAO	27 October 1995
IRAC95-106	"Request for Proposal to the University of Arizona for Science Support and Optical Component Evaluation for the SIRTF Infrared Camera", SAO		27 October 1995
IRAC95-107	"Request for Proposal to the University of Rochester for Science Support and the Evaluation of InSb Array Detectors for the SIRTF Infrared Array Camera"	SAO	27 October 1995
IRAC96-101	"SIRTF SWG Meeting at JPL, 9 - 10 January 1996, Pasadena, CA"	Team	January 1996

IRAC96-102	"SIRTF/IRAC Status Meeting at Santa Barbara Research Center" Team	11 March 1996
IRAC96-103	"SIRTF Payload Working Group Meeting at University of Arizona" Team	21-22 March 1996
<b>IRAC 200-299</b>	<b>IRAC Science Requirements Documents</b>	
IRAC-201A Draft	"SIRTF IRAC Science Requirements Document " (Draft) G. Fazio et al.	20 April 1993
IRAC95-201 Rev. Draft	"IRAC-J: Near-Infrared Observations on the Infrared Survey Mission (IRIS) Science Requirements Document" Team	13 January 1995
IRAC95-201 Initial Release	"IRAC-J: Near-Infrared Observations on the Infrared Survey Mission (IRIS)Science Requirements Document" Team	20 January 1995
IRAC96-201	"SIRTF Infrared Array Camera Science Requirements Document" (in preparation)	
IRAC96-202	"SIRTF Infrared Array Camera Instrument Performance Requirements Document", Initial Revision Team	13 May 1996
<b>IRAC 300-399</b>	<b>Detector System Technical Reports</b>	
IRAC92-301	"RFP for Optical Component Evaluation and Optical Design Support" R.S. Taylor	25 February 1992
IRAC92-302	"RFP for SIRTF/IRAC Program Support and Band 1 Detector Evaluation" R.S. Taylor	25 February 1992
IRAC92-303	"RFP for 256x256 Pixel Low-Noise InSb Array Detectors for the SIRTF IRAC" R.S. Taylor	25 February 1992
IRAC92-304	"Short-Wavelength IR Array Detector Development Project, SBRC Status Review" Team	19 March 1992
IRAC92-305	"SIRTF IRAC InSb Array Detector Development Status Review Meeting at SBRC, June 11, 1992" Team	July 1992
IRAC92-306	"RFP to Santa Barbara Research Center for 256 x 256 Pixel Low- Noise InSb Array Detectors for Space Astronomy" R.S. Taylor	14 October 1992

IRAC92-307	"SIRTF IRAC InSb Array Detector Development Status Review, 29 October 1992" R.S. Taylor	November 1992
IRAC93-301	"Short Wavelength IR Array Detector Development Program Status Review, March 29, 1993 at SBRC"	Team April 1993
IRAC93-302	"Multiplexer and Detector Array Technical Status Review at Hughes Technology Center, 3 June 1993"	Team June 1993
IRAC93-303	"RFP to Santa Barbara Research Center for 256x256 Pixel Low-Noise InSb Array Detectors for Space Astronomy" Taylor	13 July 1993
IRAC93-304	"Conceptual Design Review, CRC-744 Multiplexer at Hughes Technology Center, 23 July 1993" Team	July 1993
IRAC93-305	"Request for revision of SBRC proposal PL3345-41" R.S. Taylor	9 November 1993
IRAC93-306	"RFP to SBRC for Continuation of Short Wavelength Infrared Array Detectors for Space Astronomy" R.S. Taylor	9 November 1993
IRAC94-301	"Performance Requirements" (Si:As Status Review) Terry Herter	4 February 1994
IRAC94-302	"Silicon Technology Review at Cornell University, 3-5 October 1994" Cornell University	October 1994
IRAC94-303	"10K InSb Array Detector Status Review at Santa Barbara Research Center, 17 November 1994" Team	December 1994
IRAC95-304	"10K InSb Array Detector Status Review at SBRC" Team	April 26, 1995
IRAC95-305	"July 1995 Si Technology Review"	August 1995
IRAC95-306	"SIRTF Infrared Array Camera InSb Array Development Project" Status Review at Santa Barbara Research Center Team	8 September 1995
IRAC96-301	"Multiband Imaging Photometer for the Space Infrared Telescope Facility (MIPS) CRC-696 Cold Readout Test Report"	April 1996
<b>IRAC 400-499</b>	<b>Optical System Technical Reports</b>	
IRAC91-401	"IRAC Optical Design Support, Final Report"	

	ATR	January 1992
IRAC93-401	"SIRTF IRAC Optical Design Workshop at GSFC" Team	11 February 1993
IRAC93-402	"RFP to Evans Engineering for Optical Design Updates and Packaging of an Infrared Array Camera" R.S. Taylor	14 September 1993
IRAC94-401	"RFP to Advanced Technology Research to Study an Alternative Refractive IRAC Design", (augment to Contract SV3-63005) R.S. Taylor	11 January 1994
<b>IRAC 600-699</b>	<b>Electronics System Technical Reports</b>	
IRAC93-601	"Image Sharpening by On-Chip Tracking in IRAC-2", European Southern Observatory Technical Preprint No. 53. G. Finger et al.	July 1993
<b>IRAC 900-999</b>	<b>Mission Operations Reports</b>	
IRAC92-901	"Atlas SIRTF Science and Mission Operations Design and Operations Concepts Draft 1.0" R. B. Miller	4 September 1992
<b>IRAC/TM 2000-2999 IRAC Science Requirements Technical Memos</b>		
TM92-2001	"Galactic and Extragalactic Star Formation" S.P. Willner	12 August 1992
TM92-2001A	"Revised draft chapter: Galactic and Extragalactic Star Formation" S.P. Willner	21 August 1992
TM93-2001	"Brown Dwarfs" paper presented at XIII Moriond Astrophysics Meeting ( <u>The Cold Universe</u> ) in March 1993, Les Arcs, France. W.J. Forrest	December 1993
TM94-2001	"An Analysis of Science Return vs. Aperture for the IRIS Mission" G. Fazio & E. Tollestrup	December 1994
TM96-2001	"Evaluation of a Calibration Source Located at the SIRTF Secondary Mirror" Team	January 1996
TM96-2002	"IRAC Brown Dwarf Survey - Survey Method and Optimum Integration Time" Team	January 1996
<b>IRAC/TM 3000-3999 Detector System Technical Memos</b>		
TM92-3001	"Noise Data on the CRC-643 Chip" E. V. Tollestrup	24 March 1992
TM92-3002	"Multiple Sampling Analysis" W. J. Forrest	April 1992

TM92-3003	"An Analysis of the Effectiveness of Different Sampling Schemes on 1/f and White Noise Dominated Data: A Preliminary Summary" E.V. Tollestrup	1 June 1992
TM92-3004	"Summary Report on Gateless, Si <sub>3</sub> N <sub>4</sub> Passivated Arrays FPA48 and FPA41" H. Chen, J.D. Garnett, S.L. Solomon, W.J. Forrest, J.L. Pipher, A. Helmbock	4 June 1992
TM92-3005	"Multiple Sampling Numerical Experiments" W.J. Forrest	July 1992
TM92-3006	"University of Rochester's Final Report to SAO for Contract SV1-61003: Space Technology Development for Infrared Array Camera" Univ. of Rochester	July 1992
TM92-3007	"Theoretical Analysis of Background Limited Performance for Non-Destructive Read-Out Sampling" J.D. Garnett	July 1992
TM92-3008	"Band 1 Read Noise Requirement" S.P. Willner	August 1992
TM92-3009	"Summary of Tests on the VO/CE Array" Chen, Forrest, Pipher, Garnett	1 September 1992
TM92-3010	"A Re-Analysis of Detector Thickness Determined from Narrow-Band Interference" J. Garnett, H. Chen	September 1992
TM93-3001	"Multiply Sampled Read Limited and Background Limited Noise Performance" J.D. Garnett, W.J. Forrest	April 1993
TM93-3001	"Multiply Sampled Read Limited and Background Limited Noise Revision A Performance" J.D. Garnett, W.J. Forrest	November 1994
TM93-3002	"Near Infrared Arrays for SIRTf, the Space Infrared Telescope Facility" Forrest, Chen, Garnett, Solomon, Pipher	April 1993
TM93-3003	"Investigation of Charge Trapping Effects in InSb Focal Plane Arrays" Solomon, Garnett, Chen	April 1993
TM93-3004	"Low-Noise, Low-Temperature 256x256 Si:As IBC Staring FPA" Hughes Carlsbad, NASA ARC, UR	April 1993
TM93-3005	"Summary Report on the Gated 256x256 SiO <sub>x</sub> Passivated Array FPA84" Chen, Garnett, Solomon, Forrest, Pipher	22 April 1993

TM93-3006	"58x62 Si:As IBC PMOS Detector Arrays for Astronomy" ARC, Orion TechnoScience, UCBerkeley	April 1993
TM93-3007	"58x62 Si:As IBC Detector Arrays on PMOS Multiplexers for Astronomy" ARC, Orion TechnoScience, UCBerkeley	April 1993
TM93-3008	"Initial Test Results of the Goddard Polysilicon Infrared-Source (Element A, device #2) J. Farhoomand	10 November 1993
TM94-3001	"SUTR Transfer Function" R. McMurray, Jr.	3 June 1994
TM95-3001	"Testing of 4 CRC-744 bare muxes" W.J. Forrest, J. Wu, and J.L. Pipher	24 January 1995
TM95-3002	"Proton Radiation Test Results on WIRE Arrays" McCreight/Herter	21 February 1995
TM95-3003	"Advances in Detector Technology for Infrared Astronomy" C. McCreight	June 1995
TM95-3004	"Infrared Detectors and Instrumentation for Astronomy" J.L. Pipher, W. J. Forrest, J. Wu	May 1995
TM95-3005	"Radiation Testing of InSb Array on CRC 744 Multiplexer" Univ. Rochester	8 September 1995
TM95-3006	"Ionizing Radiation and SIRTf" P. Eisenhardt	14 September 1995
TM95-3007	"Useful References for Radiation Environment Information" P. Eisenhardt	9 November 1989
TM95-3008	"A Report on the Readout Speed, Noise, and Cross-Talk of the CRC463 FPA131 Driving a 640 pF Load" Univ. Rochester	19 October 1995
TM95-3009	"Summary Performance Report - InSb Arrays, -130, -131, -133, -134, -136, -137, -40544, -40541" Univ. Rochester	27 July 1995
TM95-3010	"Effects of 30K InSb Operation on the IRAC BIB Arrays" E. Tollestrup	29 September 1995
TM96-3001	"Summary Report on Detector Array 744-40716" Univ. Rochester	24 January 1996
TM96-3002	"Power Dissipation of the CRC463 and CRC744 Muxes" Univ. Rochester	24 January 1996

TM96-3002 Rev. 1	"Power Dissipation of the CRC-463 and CRC744 Muxes" Univ. Rochester	24 January 1996
TM96-3003	"InSb Array Operating Temperature" R. Taylor	26 January 1996
TM96-3004	"Comparison of Radiation Hardness of Rockwell and Hughes Si:As BIB Arrays" (Addendum to IRAC96-103, "SIRTF Payload Working Group Meeting at Univ. Arizona" Cornell/Ames	22 March 1996

**IRAC/TM 4000-4999 Optical System Technical Memos**

TM92-4001	"SIRTF/IRAC Beamsplitter" K. Hendrix, OCLI	12 February 1992
TM92-4002	"Video Description - 3D IRAC Model: November 11, 1991" ATR	9 January 1992
TM92-4003	"Optical Design Report - IRAC4" R.S. Taylor	11 January 1993
TM93-4001	"Radiation Effects on Filters" S.P. Willner	27 January 1993
TM93-4002	"IRAC OCLI Beamsplitter Tests Model 2 S/N 1 Change in Flatness with Temperature" W. Hoffmann, P. Woida	31 March 1993
TM93-4003	"SIRTF Beamsplitter, CdTe Discontinuities" OCLI	31 March 1993
TM93-4004	"Remeasurement of the Low Temperature Distortion of OCLI Beamsplitter Model 2 Serial Number 1" W.F. Hoffmann & P.M. Woida	2 August 1993
TM93-4005	"First Experience with a Solid ZnSe Grism for Near-Infrared Astronomy" T.M. Herbst, J.T. Rayner	September 1993
TM95-4001	"IRAC Telescope Stability Requirements Including the Effects of Optical Aberrations, Pixelization, and Image Processing" E. Tollestrup	December 1995

**IRAC/TM 6000-6999 Electronics System Technical Memos**

TM95-6001	"IRAC Split Mux and Warm Electronics Redundancy" R. Taylor	16 October 1995
IRAC/TM 6000-6999	Electronics System Technical Memos Lockheed	14 November 1996